CLAIMS

We claim:

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1. The method of locating objects positioned in front of a computer controlled display area, the method comprising:

   displaying an image having corresponding image data in the display area;

   converting the image data into expected captured display area data using a derived coordinate location function and a derived intensity function;

   capturing the image in an image capture area to obtain captured data that includes captured display area data corresponding to a predetermined location of the display area in the capture area;

   comparing the expected captured display area data to the captured display area data;

   wherein non-matching compared image data locations correspond to locations of the objects.

2. The method as described in Claim 1 further comprising deriving the coordinate location function by:

   displaying a plurality of calibration images within the display area each including a calibration object having an associated coordinate location within the display area;

   capturing a plurality of images of the display area within the capture area each including one of the plurality of calibration images;

   for each captured image, mapping the coordinate location of the calibration object in the display area to a coordinate location of the calibration object in the predetermined location of the display area in the capture area; and

deriving the location function from the display area to the captured display area from the coordinate location mappings.

3. The method as described in Claim 2 further comprising deriving the intensity function by:

   displaying at least two intensity calibration objects in at least one image within the display area each having a different associated displayed intensity value;

   capturing the at least two displayed objects in the at least one image to obtain captured intensity values corresponding to the displayed intensity values;

   mapping the displayed intensity values to the captured intensity values; and

   deriving the intensity function from the intensity value mappings.

4. The method described in Claim 3 wherein displayed and captured intensity values are one of grayscale intensity values and color intensity values.

5. The method described in Claim 3 further comprising determining a look-up table representative of the intensity function using interpolation.

6. The method described in Claim 2 further comprising deriving the location function from coordinate mappings using a perspective transformation.

7. The method described in Claim 6 further comprising displaying five or more calibration images and deriving the location function using a perspective transformation having nine associated coefficients for determining a two coordinate perspective transformation.

8. The method described in Claim 1 further comprising comparing the expected captured display area data to the portion of the captured display area data corresponding to the predetermined location of the display area by:

subtracting pixel values of the expected captured display area data from corresponding pixel values of the captured display area data to obtain difference data at each coordinate location of the display area; and

for each coordinate location, comparing the difference data to a threshold noise value to identify the location of the objects in front of the display area.

9. The method as described in Claim 8 wherein the threshold noise value is dependent on lighting conditions, type of image displayed, and camera quality.

10. The method as described in Claim 1 wherein pixel values at non-matching locations of the captured display area data are set to a first intensity value and the remaining pixel values of the captured display area data are set to a second intensity value.

11. A method of calibrating a system including a computer controlled display area and an image capture area of an image capture device comprising:

displaying a plurality of calibration images within the display area each including a calibration object having an associated coordinate location within the display area;

capturing a plurality of images of the display area within the capture area each including one of the plurality of calibration images;

for each captured image, mapping the coordinate location of the calibration object in the display area to a coordinate location of the calibration object in the predetermined location of the display area in the capture area; and

deriving the location function from the coordinate location mappings.

12. The method described in Claim 11 further comprising deriving the location function from the mappings using a perspective transformation.

13. The method described in Claim 12 further comprising displaying five or more calibration images and deriving the location function using the perspective

transformation having nine associated coefficients for determining a two coordinate perspective transformation.

14. The method as described in Claim 11 further comprising deriving the intensity function by:

displaying at least two intensity calibration objects in at least one image within the display area each having a different associated displayed intensity value;

capturing the at least two displayed intensity calibration objects in the at least one image to obtain captured intensity values corresponding to the displayed intensity values;

mapping the displayed intensity values to the captured intensity values; and

deriving the intensity function from the intensity value mappings.

15. The method described in Claim 14 further comprising determining a look-up table representative of the intensity function using interpolation.

16. A system comprising:

a computing system;

a display area controlled by the computing system to display an image in the display area having corresponding image data;

an image capture device for capturing the image within a capture area to obtain captured data that includes captured display area data corresponding to a predetermined location of the display area in the capture area;

an object locator including:

an image data converter for converting the displayed image data into expected captured display area data using a derived coordinate location function and a derived intensity function;

a means for comparing pixel values of coordinate locations of the expected captured display area data to corresponding coordinate locations in the captured display area data;

wherein non-matching compared image data corresponds to locations of non-displayed image objects in front of the display area.

17. The system as described in Claim 16 wherein the coordinate mapping function is derived from the mappings using a perspective transformation.

18. The system as described in Claim 16 wherein the display area is one of a projection screen and a computer monitor and the image capture device is one of a digital still camera, a digital video camera, an analog still camera, and an analog video camera.

19. The system as described in Claim 16 further comprising a means for predetermining the location of the display area in the capture area by deriving constructive and destructive feedback data from image data corresponding to a plurality of captured calibration images.

20. An apparatus for locating an object in front of a display area in a user interactive, computer controlled display system including an image capture device having a corresponding capture area comprising:

a means for converting image data corresponding to an image displayed in the display area into expected captured display area data using a derived coordinate location function and a derived intensity function;

a means for comparing pixel values of coordinate locations of the expected captured display area data to corresponding coordinate locations in captured data corresponding to a predetermined location of the display area within the capture area;

wherein non-matching compared image data corresponds to locations of objects in front of the display area.

21. The apparatus as described in Claim 20 wherein the means for comparing pixel values comprising:

a means for subtracting expected captured display area data pixel values from captured display area data to obtain a difference value for each pixel location of the displayed image;

a means for comparing the difference value to a threshold value;

wherein, for a given compared pixel location, if the absolute difference value is greater than the threshold value then an object is located in front of the given pixel location.

22. The apparatus as described in Claim 21 wherein the threshold value is dependent on lighting conditions, type of image displayed, and camera quality.

23. The apparatus as described in Claim 20 further comprising a means for predetermining the location of the display area in the capture area by deriving constructive and destructive feedback data from image data corresponding to a plurality of captured calibration images.